CHEMICAL HAZARD SUMMARY

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Hexamethylene Diisocyanate (HDI) Polyisocyanates Made From HDI

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SCOPE OF THE DOCUMENT

This document focuses on the hazards of HDI and polyisocyanates made from HDI. The toxicity, fire hazards and reactivity of these materials are described. Information about protective measures, storage, handling, clean-up, disposal, sampling and analysis is also given. The relevance and perspective of the information for the workplace is emphasized. Special attention is given to the main hazard presented by these materials.

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I. MAIN HAZARD

HDI and polyisocyanates made from HDI can cause respiratory sensitization. People with this potentially disabling condition can experience severe asthmatic symptoms when they breathe in even very low levels of isocyanate vapour or mist (see Section III – Effects of Long-Term Overexposure in Humans).

Excessive levels of HDI and polyisocyanates made from HDI in the air cause respiratory system irritation when they are inhaled. Very high exposures could prove fatal (see Section III – Effects of Short-Term Overexposure in Humans).

II. OCCUPATIONAL EXPOSURE

Hexamethylene diisocyanate (HDI) is a colourless to slightly yellow liquid with a sharp, pungent odour. Its main use is to manufacture certain polyisocyanate compounds. These are used in polyurethane (urethane) coatings such as paints for vehicles, aircraft and boats[1]. HDI may also be used as an ingredient in the preparation of dental materials, contact lenses and medical adsorbents.

There are two main types of polyisocyanates made from HDI. These are called biuret-type and isocyanurate-type HDI polyisocyanates. Both of these types of materials are clear to slightly yellow liquids. Some of these materials are sold dissolved in hazardous solvents.

The polyisocyanates contain small amounts of pure HDI left behind from their production processes. Freshly made HDI biurets typically contain less than 0.7% HDI. The HDI level may increase to 1.6% during storage. This is more likely to occur if they are stored at higher temperatures. HDI isocyanurates usually contain less than 0.3% HDI when they are first produced. This level does not increase during storage[2].

People can be exposed to HDI and HDI polyisocyanates as follows:

Liquid:	Skin or eye contact, swallowing (ingestion)
Mist (such as spray mist):	Inhalation, skin or eye contact
Vapour:	Inhalation, eye contact

General information on routes of exposure is available in the CCOHS document "How Workplace Chemicals Enter the Body"[3].

At room temperature, liquid HDI gives off enough vapour to cause harmful effects on the respiratory system. This is not usually a problem with the polyisocyanates made from HDI. However, breathing in sprayed polyisocyanates could cause severe respiratory problems[1,4]. Many reports of health effects blamed on overexposure to HDI are most likely the result of breathing excessive levels of polyisocyanates made from HDI[5].

Other isocyanate chemicals are often used to produce polyurethane coatings. These include polyisocyanates made from toluene diisocyanate (TDi), methylene bisphenyl isocyanate (MDI) or isophorone diisocyanate (IPDI). Pure TDI, MDI or

IPDI could also be present. To further complicate the picture, polyurethane coatings may contain mixtures of different isocyanate chemicals including HDI polyisocyanates.

It is important to know exactly what isocyanates are present to ensure accurate measurements of isocyanate exposure.

HDI and polyisocyanates made from HDI are most often used with other materials including solvents. These other materials can also be health hazards. Some of them are possible fire or explosion hazards. Others may be both health and fire or explosion hazards.

Material Safety Data Sheets (MSDSs) should be available from the manufacturer or supplier of the materials. These MSDSs should give details of the chemical ingredients, including isocyanates, contained in the material. The MSDSs should also give the possible health and safety hazards of the material and what needs to be done to control these hazards.

Read and understand the MSDSs and labels for each material before it is used.

III. HEALTH HAZARDS

Effects of Short-term Overexposure in Humans

Inhalation

Breathing excessive levels of HDI or HDI polyisocyanate vapour or mist can irritate the nose, throat and lungs. Effects on the respiratory system depend on the amount of HDI, HDI polyisocyanates and/or other isocyanates present in the air. The irritation is more severe with increasing airborne levels[2,5].

Respiratory irritation may first be noticeable at HDI levels of 0.05 to 0.1 ppm (parts of HDI per million parts of air). Symptoms include a burning sensation in the nose and throat, and a sore throat. Coughing which may produce phlegm, discomfort, a feeling of chest "tightness", breathlessness and difficulty in breathing can also occur.

Higher levels of isocyanates may produce chemical bronchitis with contractions of the airways of the lungs. This results in severe coughing spasms and wheezing. Very high levels of isocyanates can produce inflammation of the lungs (chemical pneumonitis) and build-up of fluid in the lungs (pulmonary edema) which could prove fatal[2,5,6].

Symptoms may occur at the time of exposure, or they may be delayed for several hours following the exposure[5]. There are no reports indicating how long the symptoms last. However, people who have suffered respiratory irritation from short-term high-level exposures to toluene diisocyanate (TDI), another widely used isocyanate, have usually recovered within a few weeks[5].

It is not clear whether HDI is more irritating than HDI polyisocyanates.

It appears that some people may develop respiratory sensitization following a single very high-level exposure to HDI or HDI polyisocyanates while spray painting[2,7,8].

Eyes
The liquid, mist or vapour from HDI or polyisocyanates made from HDI can irritate the eyes producing pain, watering and redness. HDI levels as low as 0.05 to 0.1 ppm can cause a burning sensation and watering of the eyes[2].

HDI applied to rabbit eyes causes severe irritation and damage to the front part of the eye (cornea)[9,10]. HDI polyisocyanates containing less than 0.7% HDI cause moderate eye irritation when applied to rabbit eyes[2].

Skin
Liquid HDI and HDI polyisocyanates can irritate the skin. HDI causes severe skin irritation when applied to rabbit skin for 24 hours. Effects include skin redness, severe swelling and some damage to tissue beneath the skin. Polyisocyanates made from HDI which contain less than 0.7% HDI produce slight to moderate skin irritation when applied to rabbit skin[2,9,10].

Ingestion
There are no reports of people swallowing (ingesting) HDI or any polyisocyanates made with HDI, and this is unlikely to happen in the workplace. Animal studies indicate that these materials are not very toxic when they are ingested. Swallowing them might cause irritation to the mouth, stomach and digestive tract[2].

Effects of Long-term Overexposure in Humans

Carcinogenic Effects
There are no reports indicating that HDI or HDI polyisocyanates cause cancer in people who work with them.

Effects on the Respiratory System
Respiratory sensitization can develop in people working with HDI or polyisocyanates made from HDI. This condition is different from respiratory irritation caused by isocyanates. People sensitized to isocyanates can react to very low levels of airborne isocyanates that have no effect on unsensitized people.

The effects of respiratory sensitization are similar to asthma. Common sensitization symptoms include cough, wheezing, feelings of chest tightness, difficult breathing, chills, headache and general feelings of bodily discomfort. Breathlessness, shortness of breath, a burning sensation in the chest and pain in the joints may also occur. Asthmatic symptoms have been severe enough to require hospitalization[11-14].

An individual might experience symptoms immediately after exposure to airborne HDI or HDI polyisocyanates, as much as ten hours after exposure or both[11-13]. Many people experience effects after leaving work for the day. This can make it difficult to associate health problems with isocyanate exposure at work.

Symptoms may subside after a few hours away from any isocyanate exposure. However, effects can persist for as long as two weeks[7, 12]. In fact, some sensitized people continued to suffer respiratory problems for at least 18 months after their last exposure to HDI or HDI polyisocyanates. These effects included difficulty in breathing and chest tightness during or after exercise or after exposure to dusts or irritating vapours such as turpentine[7,8,13].

Sensitized people who continue to be exposed to these isocyanates may develop symptoms sooner and sooner after each exposure. The number and severity of their symptoms may also increase. It could also take them longer to recover from their symptoms after they are removed from exposure[4,7,13].

The causes of respiratory sensitization to isocyanates are not completely understood. Responses of the body's immune system may be involved[5]. Both allergy-prone and non-allergy-prone people can become sensitized to HDI and HDI polyisocyanates[4,11-13].

Some people may develop respiratory sensitization after only one exposure to very high levels of HDI or HDI polyisocyanates [2,7,8]. In other people, sensitization can develop within the first few months of working with these materials after repeated exposures at lower levels[2].

All of the reported cases of respiratory sensitization to HDI or polyisocyanates made from HDI involve spray painters. Spray painting can result in very high levels of airborne HDI and HDI polyisocyanates[4,15].

In general, information on the isocyanate levels needed to produce sensitization is lacking. But it is likely that the chances of becoming sensitized are greater with increased levels of exposure.

It is not clear whether HDI biurets are more likely to cause respiratory sensitization than HDI isocyanurates or whether either of these polyisocyanates is a more powerful sensitizer than HDI. During spray painting operations involving these compounds, HDI polyisocyanates are present in much larger amounts than HDI.

Cross-sensitization between different isocyanate chemicals can occur. This means that people sensitized to one isocyanate chemical can suffer similar symptoms when they inhale a different isocyanate chemical that they have never been exposed to. People with respiratory sensitization to TDI have shown sensitization to HDI and MDI (methylene bisphenyl isocyanate) where no previous exposure to HDI or MDI was known[16]. One person sensitized to HDI-containing enamel showed respiratory sensitization to PMPPI (polymethylene polyphenyl isocyanate) when no previous exposure to this material was known[12]. A sensitized spray painter who worked with paints containing HDI polyisocyanates or TDI polyisocyanates suffered the same symptoms when he inhaled either of these materials[4].

People working with HDI and polyisocyanates made from HDI could inhale other materials such as solvents as well as isocyanates. It is not known whether these other chemicals increase the chances of developing respiratory sensitization.

Effects on the Skin
Repeated or prolonged skin contact with HDI or HDI polyisocyanates may result in skin sensitization. This reaction is an allergic dermatitis. Symptoms could include a rash, itching, hives and swelling of the arms and legs if even a small amount of these isocyanates touches unprotected skin[2].

Toxicity Data in Animals and Laboratory Tests

Lethal Dose Values
The poisoning strength of a compound can be estimated from the LD_{50} or LC_{50} obtained in animal tests. LD stands for lethal dose, LC for lethal concentration in air. The LD_{50} is the amount of a chemical (weight of chemical per weight of animal) which is needed to kill 50% of the test animals. The LC_{50} is the concentration in air which kills 50% of the animals following an exposure lasting 4 hours or another indicated time period. Test animals are usually rats, mice or other rodents. Routes of exposure are usually by mouth (oral), through the skin (dermal) or by breathing in the airborne chemical (inhalation). The values obtained for these materials by different researchers are:

(i) **HDI**

LC_{50} (rat, inhalation):	310 350mg/m^3*; 4-hour exposure duration[17]
LC_{50} (rat, inhalation):	385 mg/m^3; 6-hour exposure duration[18]
LC_{50} (mouse, inhalation):	30 mg/m^3; 2-hour exposure duration[18]
LD_{50} (oral, rat):	710-1 050 mg/kg**[17,18]
LD_{50} (dermal, rabbit):	570 mg/kg**[18]

(ii) **HDI Polyisocyanates**

LC_{50} (rat, inhalation):	91-1 150 mg/m^3; 4-hour exposure duration[2,19]***
LD_{50} (oral, species not stated):	19 800 mg/kg[17]****

*Milligrams of chemical in one cubic meter of air
**Milligrams of chemical per one kilogram of the test animal's weight
***Results from testing several different HDI polyisocyanates
****Result from testing one HDI biuret polyisocyanate product

These results indicate that:

1. HDI and HDI polyisocyanates are very toxic when they are breathed in.

2. HDI and HDI polyisocyanates are not very toxic when they are swallowed.

3. HDI is toxic when it is applied to the skin.

Further general information on the LD_{50} is available in the Centre's publication "What is an LD_{50}?"[20]

Other Animal Data
HDI and HDI biuret cause respiratory tract irritation in mice. The irritating effects increase as the time and level of exposure to the chemicals increase[19,21].

HDI can cause skin sensitization in guinea pigs[18].

A mutation is a change in the genetic material in a cell. Genetic mutations may lead to birth defects or cancer. HDI did not cause genetic mutations in bacteria in a short-term test (Ames test)[22]. In a similar study, one HDI biuret product did not cause genetic mutations[17]. More testing, including animal tests, is required to determine whether or not HDI and polyisocyanates made from HDI cause birth defects or cancer.

In test tube experiments, HDI can affect an enzyme important for nerve impulse transmission. This might partly explain some effects of HDI on the respiratory system[23].

IV. FIRE AND EXPLOSION HAZARDS

HDI and HDI polyisocyanates are not flammable under normal conditions. However, if heated strongly, they will evaporate and burn. Toxic carbon monoxide, oxides of nitrogen and traces of hydrogen cyanide may form when they burn. HDI polyisocyanate products containing solvents may be more flammable due to the solvent vapours.

The fire hazard can be estimated by the flash point of the substance. The flash point for some typical HDI polyisocyanates (not in solvents) is 170°C (338°F)[2]. The flash point of HDI is about 135-140°C (275-284°F). When the material is at or above this temperature, enough vapour is produced to form a flammable or explosive mixture of vapour and air. A spark, flame or other ignition source can cause this mixture of vapour and air to burn or explode.

The auto-ignition temperature is the lowest temperature at which a material begins to burn in air in the absence of a spark or flame. The auto-ignition temperature for HDI is 454°C (849°F).

Fire Extinguishing Agents
Large fires involving HDI and polyisocyanates made from HDI can be extinguished with water spray. Use very large quantities of water since the reaction between water and hot isocyanates can be vigorous.

High expansion chemical foam, carbon dioxide or dry chemical extinguishers can be used for smaller fires[2].

V. CHEMICAL REACTIVITY

Isocyanates can react readily with compounds such as water, ammonia, amines and alcohols. Strong bases such as tertiary amines, caustic soda and potash can speed up reactions. This could result in an uncontrolled polymerization reaction. The heat and products that result from this reaction can cause a pressure build-up in closed containers that might rupture them.

At room temperature, isocyanates react slowly with water, forming carbon dioxide gas. This, too, can rupture sealed containers explosively.

Do not reseal isocyanate containers or vessels if contamination of the isocyanate is suspected[2].

VI. EXPOSURE LIMITS

Many Canadian jurisdictions have exposure limits similar to those established by the American Conference of Governmental Industrial Hygienists (ACGIH). The exposure limit proposed by ACGIH for HDI is a time-weighted average value of 0.005 parts per million (ppm) or 0.035 milligrams per cubic metre (mg/m^3). There are no ACGIH exposure limits for HDI polyisocyanates. Refer to ACGIH documentation for information on the exposure limits.

Contact the appropriate authority in your jurisdiction for details of the specific regulations which apply. Ontario and British Columbia have special workplace isocyanate regulations.

VII. EXPOSURE CONTROLS

Exposure to these isocyanates is best prevented by design of the work process and engineering controls. The available types of control measures include:

Substitution	Area ventilation
Isolation	Work practices
Enclosure	Personal hygiene
Local exhaust ventilation	Personal protective equipment

One or more of these measures may be appropriate in any particular situation. A survey of the workplace and consideration of the technical requirements of the work process are usually needed before major changes are made. Regular worker training should be conducted to ensure that all employees have current knowledge of job hazards and procedures, including emergency procedures.

Use fully-enclosed handling systems where possible. Local exhaust ventilation may be necessary in operations such as weighing, dispensing and mixing of these materials. Both spraying and non-spraying operations (expecially those involving heating) may also require local exhaust ventilation. Supply enough clean air to the work area to replace air removed by exhaust ventilation systems.

The use of airless or electrostatic spray equipment may reduce spray mist levels during spraypainting. Brush, roller and curtain coating application of coatings containing these materials may be possible in some cases[2]. Design and maintain all control systems to keep isocyanate to exposures as low as possible.

Preferred methods of control are substitution of these materials with a less toxic material (if possible) and engineering changes. Personal protective equipment increases the level of protection for workers exposed to these materials. In some situations, such as working in confined spaces and in some maintenance operations, the use of personal protective equipment may be essential since effective ventilation and engineering controls might not be possible.

Protective Clothing
Wear protective clothing (gloves, coveralls, boots, etc.) as needed to prevent skin contact. There are no specific recommendations for clothing materials that provide good resistance to these isocyanates. Contact the manufacturer/supplier of the HDI-based product you are using for best protective clothing material to use. Evaluate the effectiveness of protective clothing under actual conditions of use and maintain it carefully.

Since cured polyurethane coatings cannot be easily removed from the skin, cover as much exposed skin as possible with clothing. Apply a suitable protective skin cream to skin areas that cannot be covered by protective clothing[2].

Promptly remove clothing which becomes contaminated with isocyanates and place in a closed container. Discard or decontaminate and launder before re-wearing. Decontaminate clothing by putting it in a solution made up of 4-8% concentrated ammonium hydroxide, 2% liquid detergent and 90-94% water before laundering[18].

Wear chemical safety goggles to protect the eyes when working with these isocyanates. A face shield may also be necessary to protect the face.

Wear protective coveralls, gloves, footwear and suitable respiratory protection when working close to inadequately ventilated spray operations or wherever there is a drift of spray[18]. A safety shower and eye-wash station should be readily available wherever these isocyanates are present.

Respiratory Protection
Factors to be considered in a respiratory protection program include:

Selection of appropriate respirators
Respirator fit
Respirator maintenance
Worker training

These factors are described in more detail in CSA Standard Z94.4, "Selection, Care, and Use of Respirators," available from the Canadian Standards Association, Rexdale, Ontario, M9W 1R3.

The U.S. National Institute for Occupational Safety and Health (NIOSH)[18] recommends the following respiratory protection for diisocyanate (e.g. HDI) concentrations:

1 ppm or less: Type C supplied-air respirator (SAR) with full facepiece operated in pressure-demand or other positive-pressure mode or with full facepiece, helmet or hood operated in continuous-flow mode.

Greater than 1 ppm: Self-contained breathing apparatus (SCBA) with full facepiece operated in pressure-demand or other positive-pressure mode; or
Combination respirator including Type C SAR with full facepiece operated in pressure-demand or other positive-pressure mode with auxiliary SCBA operated in pressure-demand or other positive-pressure mode.

Fire Fighting and Emergency: SCBA with full facepiece, operated in pressure-demand or other positive-pressure mode.

Note: The above recommendations only apply to NIOSH/MSHA approved equipment.

VIII. SMALL-SCALE STORAGE AND HANDLING

Store these isocyanates in tightly-closed, labelled containers. Keep containers in a dry, well-ventilated area, out of direct sunlight. Store them away from materials that react with isocyanates. Keep containers away from heat and ignition sources. Protect them from damage. Store at manufacturer's recommended temperatures. Store these isocyanates in the smallest possible quantities.

Storage areas should have floors that do not allow spilled liquids to penetrate. Storage areas should also be diked to contain spills. Consider installing leak detection and alarm equipment.

Only allow authorized trained persons access to the storage area. Separate chemical storage areas from populated work areas. Post appropriate warning signs. Inspect storage areas regularly for any defects such as leaking containers.

Use these materials in the least possible quantities in designated well-ventilated areas. Do not use near sources of heat or sparks. Use labelled containers and keep them closed when not in use. Protect containers from damage. Do not reseal containers if contamination of the isocyanate inside is suspected. Avoid handling these isocyanates in open vessels as much as possible. Wear protective goggles, clothing and respirator suitable for the job being done. Empty isocyanate containers may be hazardous due to material remaining inside them. Decontaminate empty drums by filling them with one of the following solutions:

i) 2-5% ammonia, 2-5% liquid detergent, 0-20% isopropanol (may create a fire or vapour hazard in some situations, e.g. confined spaces; if so, do not use), balance of solution-water.

ii) 20% non-ionic surfactant (such as Union Carbide TMN-10*),
80% water[2]

* This product name is only used as an example. Mention of it in this document does not constitute an endorsement of its use or effectiveness by the Canadian Centre for Occupational Health and Safety.

Allow the drums containing decontamination solution to stand uncovered outdoors or in a safe, well-ventilated area for at least 24 hours[2]. The reaction between the solution and isocyanates liberates carbon dioxide gas that could rupture tightly-closed containers.

Decontaminate (using above solutions i or ii) and clean isocyanate handling equipment after use.

Dispose of decontaminant solutions according to local environmental regulations.

In general, these isocyanates should be stored and handled in ways which minimize the risks of spillage and the release of vapour or particles into the workplace air.

IX. FIRST AID

The following general procedures are suggested for first aid involving poisoning by HDI or polyisocyanates made from HDI:

Inhalation
Take proper precautions to ensure your own safety before attempting rescue; for example, wear appropriate protective equipment, use the "buddy" system. Remove source of contamination or move victim to fresh air. Obtain medical attention immediately.

Skin
Avoid direct contact with this chemical. Wear impervious protective gloves and respiratory protection if necessary. Remove contaminated clothing, shoes and leather goods (for example watchbands, belts) and place in covered container. As quickly as possible, flush contaminated area thoroughly with lukewarm, gently running water. The material can be removed with a clean cloth and isopropyl alcohol, followed by soap and water[2]. Obtain medical attention immediately.

Eyes
Gently blot or brush away excess chemical quickly. Immediately flush the contaminated eye(s) with lukewarm, gently flowing water for 20 minutes, by the clock, holding the eyelid(s) open. Obtain medical attention immediately.

Ingestion
Never give anything by mouth if victim is rapidly losing consciousness or is unconscious or convulsing. Rinse mouth thoroughly with water. DO NOT INDUCE VOMITING. Have victim drink about 250 ml (8 ounces) of water to dilute material in stomach. If vomiting occurs naturally, have victim lean forward to reduce risk of isocyanate entering the lungs. Repeat administration of water. Obtain medical attention immediately.

Note: Consult a physician and/or the nearest Poison Control Centre for all cases of ingestion or eye contact and all but trivial cases of inhalation or skin contact.

All first aid procedures should be periodically reviewed by a physician familiar with these isocyanates and their conditions of use in the workplace.

X. CLEAN-UP AND DISPOSAL

HDI and polyisocyanates made from HDI are potentially very hazardous materials. Exposures associated with isocyanate spills can be high and could cause serious health problems. A plan should be established to deal with emergencies such as isocyanate spills or leaks. Trained crews should be available to handle emergencies. The isocyanate supplier or manufacturer can provide advice on how to deal with emergency situations.

Minor spills are spills that can be handled by the people and equipment available at the workplace. A major spill is one that requires help from outside sources such as the supplier/manufacturer, police or fire services. For emergency situations call the emergency phone number given in the manufacturers material safety data sheet.

The following general actions can be useful if an isocyanate spill occurs: Evacuate the spill area. Provide assistance to injured or contaminated persons. Do not allow unauthorized people into the area of the spill until clean-up operations are finished. Wear personal protective equipment, including a proper respirator, to minimize exposure to isocyanates. Notify government occupational health and environmental agencies.

Eliminate all ignition sources and ventilate the spill area. Do not touch the spilled material. Stop or reduce the rate of leaking if it can be done safely. Move leaking containers outdoors or to an isolated well-ventilated area and transfer the contents to a clean, undamaged container if it can be done safely. Prevent material from spreading or entering sewers or confined spaces by diking with earth, sand or commercially available non-reactive sorbent materials. Liquid isocyanates in drains can cause blockage because solid residues form as a result of the isocyanate/water reaction.

Use decontaminant solution (i or ii in Storage and Handling) to decontaminate spilled material. The total weight of decontaminant solution used should be greater than the weight of spilled isocyanate. Heat and carbon dioxide gas result

when isocyanates react with the solution. Use clean, undamaged, labelled, open containers to hold clean-up residues.

Minor spills: Cover spill with sand, earth or non-reactive absorbent material. Slowly, with stirring, pour decontaminant solution onto the spill. Allow to react for 10 minutes. Shovel all residues into open containers. Remove them to a safe well-ventilated area.

Major spills: Contact local police, fire services and the chemical supplier for assistance, especially if on-site decontamination is impractical.

Carefully add extra decontaminant solution to each open container holding spill residues to ensure all isocyanate has reacted. Store open or *loosely* covered containers at least 48 hours before disposal. Wash down the spill area with decontaminant solution[2]. Decontaminate emergency equipment. Test the air for isocyanate vapour. When safe working conditions have been established, resume normal operations.

Consult local environmental authorities before disposal of material containing isocyanates.

XI. SAMPLING AND ANALYSIS

A variety of sampling and analysis methods are available to determine airborne levels of HDI and polyisocyanates made from HDI[15,18,24,25,26]. Select the most suitable of the methods and the best sampling strategy for a particular operation using these materials.

Problems have been encountered with some of these sampling and analysis methods. NIOSH proposes to discontinue Method 5505[26].

Sampling flow rates of at least 2.0 litres per minute may be necessary for sampling *both* vapour and aerosols (e.g. spray paint mist) when midget impingers are used[18].

Direct reading instruments are available which respond to HDI vapour. Care should be taken in interpreting readings from such instruments where exposure to mixed isocyanates or isocyanate aerosols occurs[27].

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Note: Additional references on this subject are available from CCOHS upon request.

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